Treatment of lumbar instability by posterior interbody cage fusion and transpedicular fixation

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Background

The primary goal of intervertebral body fusion is not only correcting segmental deformity and restoring stability to the spine segment, but to provide an environment for successful fusion with a low rate of morbidity or complication. Posterior lumbar interbody fusion (PLIF) has been the standard procedure for the treatment of lumbar instability. PLIF with cage filled with iliac bone graft and transpedicular fixation add more concern regarding fusion rates, preservation of disk space height, and the clinical outcome.

Aim

The aim of this study was to assess the results of PLIF with disk cages in the treatment of lumbar instability clinically and radiologically.

Patients and methods

Fifteen patients suffering from lumbar instability were operated upon according to this technique. They were 10 female and five male patients. Clinical and radiological assessment of patients as per the Japanese scoring system was performed preoperatively and at 3, 6, and 12 months postoperatively. Polyetheretherketone cages filled with iliac bone graft were used. The levels operated upon were L4–L5 in 10 patients, L3–L4 in three patients, and L5–S1 in two patients.

Results

Marked clinical improvement in back and leg pain was noticed. Postoperative assessment by the Japanese scoring system was as follows: 22 points (73%) in eight patients, 20 points (65%) in four patients, 18 points (58%) in two patients, and 14 points (46%) in one patient. Fusion occurred in all patients.

Conclusion

PLIF with cage and transpedicular fixation result in a high fusion rate and preservation of disk space height and good clinical outcome.

Keywords:

lumbar instability, posterior interbody cage, transpedicular fixation

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Introduction

One of the major objectives of spinal fusion is to relieve pain arising from spinal structures by removing potentially pain-generating disk tissue and stabilizing one or more motion segments.

Spinal instability is a term used in general for a variety of traumatic, developmental, neoplastic, hereditary, and degenerative insults to the axial skeleton. Lumbar instability refers to the loss of the spine's ability, under physiologic loads, to maintain its pattern of displacement, causing neurologic deficits, incapacitating deformity, and intractable pain [1–5].

Instability is diagnosed clinically and radiologically by plain radiograph including anteroposterior lateral, oblique views and dynamic views, computed tomography, myelography, and MRI. The indication for spine fusion is simply and solely to eliminate instability of the spine. The instability may be real or potential and can be due to many pathologic causes. These include trauma, with injury to bone and ligamentous structures of the spine, deformity in either the sagittal or the coronal plane of the vertebral body and disk destruction from tumor or infection, degenerative deterioration of the motion segment and iatrogenic causes such as postlaminectomy, and loss of posterior elements and motion segment destruction. Many techniques of spinal fusion in the lumbar spine are available, including posterior procedures with or without internal fixation. The most important components for the successful outcome of spine fusion are appropriate patient selection and achievement of a biologic bony fusion. Fusion is an evolving area of spine surgery, and intense evaluation of its outcomes and cost-effectiveness is ongoing [3–7].

The most common solution to spine nonunion problems has been mechanical. However, controlling the local biomechanical environment at a fusion site using internal fixation has not eliminated nonunions; cloudy biologic factors must be implicated [6–10].

Theoretical advantages of the bone fusion obtained with posterior lumbar interbody fusion (PLIF) include the following: fusion occurs at approximately the center of motion; the graft is subjected to compressive rather than tensile forces; a wide area of bone surface is involved; and an excellent source of blood supply is obtained through the cancellous portion of the vertebral body when the cortical end-plates have been removed partially or totally. Placement of the bone graft or fusion cage maintains the interbody height, preserves patency of the lateral spinal canal, improves anatomic relationships among different vertebral elements, and, after successful fusion, limits mechanical tract on the nerve root from the surrounding scar tissue. A successful fusion also arrests microinstability and hypertrophic degenerative changes, thus removing the impetus for progressive tropism and stenosis. Excision of the entire disk prevents recurrent disk herniation and may reduce the rate of additional surgery [8,9].

A successful PLIF, therefore, maintains disk height, protects nerve roots, immobilizes the unstable degenerated disk area, and restores weight bearing to ventral structures, the annulus to tension, and every normal mechanical function of the spinal unit except motion [11–13].

In this work, we treat the instability by posterior lumbar interbody cage fusion and transpedicular fixation to stabilize the lumbar spine to rehabilitate the patient.

Patients and methods

From 2005 to 2010, 15 patients were operated upon by posterior interbody cage fusion and transpedicular fixation for managing lumbar instability secondary to degenerative spondylolisthesis or postlaminectomy instability to evaluate the effectiveness and safety of the procedure. They included 10 female and five male patients, with their age ranging from 25 to 65 years and a mean of 43.5 years. The duration of follow-up ranged from 6 to 22 months.

Patients with severe, disabling intractable back pain, degenerated disk spaces with resultant pain, an absence of disk space or systemic infection, no previous interbody arthrodesis at the target levels, an absence of degeneration at adjacent neighboring disk spaces, and grade I spondylolisthesis were selected for this procedure.

Patients with severe symptomatic adhesive arachnoiditis, severe osteoporosis, recent discitis, and severe subchondral sclerosis with no viable bone marrow tissue seen on MRI were excluded. Careful history and physical examination, in addition to appropriate laboratory and radiologic investigations, are required to make the correct diagnosis. Plain radiograph including anteroposterior, lateral, and dynamic views (flexion and extension) and MRI were performed for all patients.

General examination including medical and surgical problems were important. Causes of instability were postlaminectomy instability in five patients (33.3%) and degenerative spondylolisthesis in 10 patients (66.7%).

The surgical technique

The patient is placed in the prone position. A care-operative spinal frame or table must be used to prevent pressure on the abdomen because this may cause venous engorgement, stasis, and increased bleeding from the epidural veins. A midline skin incision of ~10 cm is made slightly rostral to the pathologic disk space. Dissection is carried down to the level of the lumbosacral fascia, which is opened along the midline. The spinous processes and the lamina of the vertebra above and below the level of the pathology are exposed and cleaned of all soft tissues. A deep notch is made only in the lamina of interest. Special instruments such as the vertebra spreader, a self-retaining retractor inserted between the spinous processes in the midline, allow excellent exposure of the intervertebral space. Removal of the lower one-third of the inferior facet and the medial two-thirds of the superior facet widens the exposure of the spinal canal and allows visualization of the lateral half of the intervertebral disk and provides adequate exposure of the nerve roots above and below the disk space. Preparation of the disk space for PLIF requires sufficient release of possible scar tissue and adhesions to allow mobilization of the thecal sac, to the midline from either side. After the dural sac and superior and inferior nerve roots are retracted to the midline, they must be protected during the exposure and procedure in the disk space; self-retaining nerve root retractors specifically designed for this purpose can be used in this stage of the operation. Considerable care must be taken to avoid overdistraction and traction of the neural structures during any of these steps. The disk space is entered, and an 8-mm intradiscal shaver is inserted on one side, parallel to the end-plates, and rotated a number of times. These shavers have side-cutting flutes and blunt ends so that disk material and end-plate are removed without the risk of penetrating the annulus fibrosus ventrally. By alternating sides in 1-mm increments, the shavers also result in distraction of the disk space. This also leads to the disk space being aggressively cleaned of disk material bilaterally. Preparation of the host graft site and removal of the cartilaginous end-plates are important steps to ensure successful fusion. The lumbar cortical end-plates are thinner in young patients; therefore, when a young patient undergoes PLIF, curetting to the level of oozing cortical bone is often sufficient to ensure adequate vascularization of the grafts. In older patients with matured cortical end-plates, however, it is suggested that many islands of decortication to the cancellous bone are created. Because blood is supplied to the end-plate by end arteries, the removal of a thin layer of cortical bone sufficient to change the color from white (cortical end-plate) to a brownish shade (subcortical cancellous bone) is sufficient to ensure an adequate blood supply. Because the bone texture is more porous in the central portion of the vertebral body, partial decortication prevents the graft from settling into the softer cancellous bone intradecortication down to the anterior longitudinal ligament, and should be avoided because it carries with it the risk of vascular injury. The preliminary pedicle entry sites are checked and verified with C-arm fluoroscopy. At this point, necessary adjustments can be made and the pedicles are then probed, tapped, and screwed under fluoroscopic guidance. When tapping the pedicle, it is important to remember that if the entry site has been chosen correctly, then the tap will almost guide itself down the pedicle. After tapping, the screw is placed and should follow the tapped channel easily. The pedicle screw depth can be estimated by lateral fluoroscopy.

When the disk space has been cleaned adequately, the polyetheretherketone cage filled with iliac bone graft material is inserted. Generally speaking, the cages are held in the interspace mainly by axial intervertebral forces. Therefore, it is crucial that the disk space be maximally distracted before the cages are inserted. The interbody cages are relatively fixed by the combination of the recoil force of the annulus, gravity, and the effect of muscle pull. During cage insertion, the distraction instruments are removed to allow the fused segment to compress to prevent graft extrusion. Closure of the wound is carried out with a suction drain (Figs. 1 and 2).

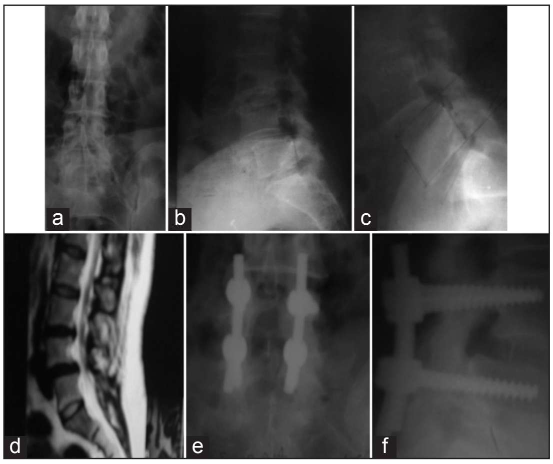
Results

All patients presented with back pain affecting daily activities, and of them, three patients presented with neurological symptoms. The mean dynamic instability in 4 mm as proved by dynamic views. The levels of instability were L4–L5 in 10 patients (66.7%), L3–L4 in three patients (20%), and L5–S1 in two patients (13.3%). In this study, patients were evaluated according to the Japanese scoring system. Preoperative assessment by the Japanese scoring system was as follows: 14 points (46%) in three patients, 12 points (40%) in eight patients, 9 points (31%) in two patients, and 8 points (28%) in two patients.

Postoperative assessment by the Japanese scoring system was as follows: 22 points (73%) in eight patients, 20 points (65%) in four patients, 18 points (58%) in two patients, and 14 points (46%) in one patient.

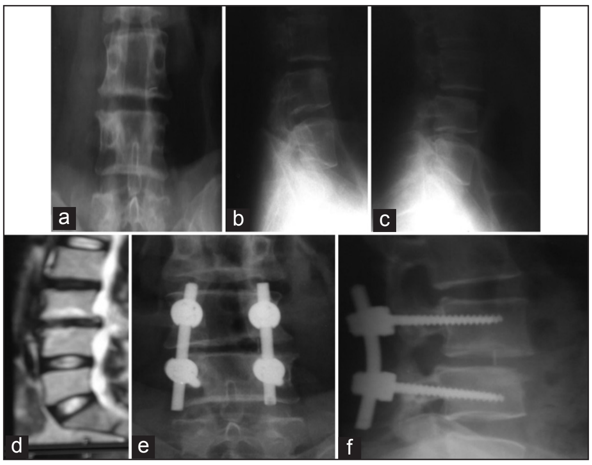
(1) Back pain: improvement of pain in 12 patients (80%); occasional pain in three patients (20%).
(2) Leg pain: improvement of pain in 10 patients (66.7%); occasional pain in five patients (33.3%).
(3) Restriction of dial activities: no restriction in 12 patients (80%); moderate restriction in three patients (20%).
(4) Fusion occurred in all patients.

Figure 1



(a) Anteroposterior view. (b) Flexion view showing instability of L4. (c) Extension view. (d) MRI showing L4–L5 disk protrusion and instability. (e) Postoperative anteroposterior view showing cage and pedicular fixation. (f) Postoperative lateral view showing cage and pedicular fixation.

Figure 2



(a) Anteroposterior view showing laminectomy L3 (b) Flexion view. (c) Extension view. (d) MRI showing L3–L4 disk protrusion and instability. (e) Postoperative anteroposterior view showing cage and pedicular fixation. (f) Postoperative lateral view showing cage and pedicular fixation.

The radiological signs of successful fusion after intervertebral fusion cage surgery were as follows:

(1) Absence of any discernible movement at the intervertebral segment as visualized on dynamic flexion–extension conventional radiographic filming.
(2) Absence of either a radiolucent halo surrounding the disk cage or marked new sclerosis of the end-plates as seen on lateral conventional radiographic images.
(3) Bone visible inside and surrounding the cages within the disk space.

Complications

Dural tear occurred in three patients with postlaminectomy instability, and was treated by repair with 4/0 silk. Malplacement of one screw occurred in one patient, and two patients had persistent thigh pain.

Discussion

Spinal fusion is an important procedure in the management of the spine disorders [12].

The indication of spine fusion is to eliminate instability of the spine. Lumbar instability represents a specific state of a structure in which the addition of a small load results in an excessively large displacement in an unpredictable or erratic manner [14–16].

The most common levels to be operated upon with PLIF in our study were L4–L5 in 10 patients (66.7%), L3–L4 in three patients (20%), and L5–S1 in two patients (13.3%).

Revision surgery of the spine, especially after multiple recurrences, is a demanding and difficult surgery; however, its poor outcome seems to be fated after the recent techniques of fusion and instrumentation [15–17].

Jun [18] reported 36 patients with lumbar instability with different causes: 20 patients with degenerative spondylolisthesis and 16 patients with postlaminectomy instability, with the most common levels of instability being L4–L5 in 22 patients, L5–S1 in nine patients, and L3–L4 in five patients treated by PLIF; the mean follow-up was 14 months, with excellent results in 28 patients and fair results in eight patients.

Rapoff *et al.* [19] reported excellent results in 30 patients with lumbar instability treated by PLIF and transpedicular fixation, with their age ranging from 49 to 67 years.

In our study, internal fixation was performed for all patients in the form of transpedicular fixation, which was very important for stability and fusion. The combination of PLIF and internal fixation has aided in preventing cage migration and to avoid loss of disk space height.

Fusion of the posterior elements of the lumbar spine combined with the placement of instrumentation represents a valid solution for spinal instability and may result in fusion in most cases.

Moller and Hedlund [20] reported 77 patients treated with instrumented and noninstrumented posterior fusion and concluded that the use of supplementary fixation did not add to the fusion rate or improve the clinical outcome.

France *et al.* [21] reported 71 patients treated with instrumented and noninstrumented posterior fusion, with the most common levels of instability being L5–S1, followed by L4–L5, and concluded that there was no statistical difference in patients' reported outcome between the instrumented and the noninstrumented groups.

Regarding the safety of PLIF, there was a high risk for neural injury, especially in patients with postlaminectomy instability due to nerve root adhesion, but it was easier after partial facetectomy because it provided a wide interspace to insert disk cages.

The degree of fusion was assessed both clinically and radiologically, but we depended on clinical assessment more than on radiological appearance of union. We relied on postoperative clinical outcomes such as absence of back pain and other related complaints.

Regarding complications, dural tear occurred in three patients with postlaminectomy instability, and were treated by repair with 4/0 silk; three patients suffered excessive blood loss and were compensated with blood transfusion. Malplacement of one screw occurred in one patient, and two patients had persistent thigh pain.

Boxall *et al.* [22] reported a series of 30 patients with lumbar instability treated with PLIF, at a rate of success of 75%,with three patients suffering excessive blood loss, two patients with pseudarthrosis, and one patient with deep infection.

Blumenthal and Ohnmeiss [23] concluded in his results that those performing interbody procedures must be trained properly in patient selection, the general operative technique, selection of device size, and correct device placement. There is good support to the fact that the cages can be used safely as stand-alone devices; however, there are reports of the need for posterior supplemental fixation. The need for such supplementation should be determined at the individual surgeon's discretion. Also, the technique should be determined on the basis of the patient's anatomy, history, and the surgeon's training, experience, and preference.

Tsuang *et al.* [24], in his results, concluded that posterior instrumentation decreases at least half the distortion stress of the cage–end-plate interface and facet joints, and diminishes the differences between the stresses of inserting one or two cages. During one cage insertion, adding posterior instrumentation provides more efficient stability than an additional cage. Furthermore, an obliquely inserted cage with posterior instrumentation produced lower stress than a cage inserted on one side because of better structural symmetry. In conclusion, one oblique anterior cage and bilateral posterior pedicle screws reconstructed the tripod system as the intact disk and facet joints, and provided a stability similar to that provided by two cages.

Conclusion

PLIF and transpedicular fixation is an effective treatment for patients with symptomatic degenerative disk disease, spondylolisthesis, and other painful discogenic syndromes. Fusion of the degenerative and unstable lumbar spinal motion segment can yield significant relief from this disabling and often progressive condition. PLIF limits the extent of posterolateral soft tissue exposure, muscle stripping, and injury. With this technique, the surgeon uses the traditional posterior approach to the lumbar spine; however, dissection is limited laterally to the facet joints. Through this approach, direct neural decompression can be completed, disk space height and sagittal balance can be restored, and intervertebral grafts can be placed in a biomechanically advantageous position.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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